

**IN THE SPECIFICATION:**

Page 1, immediately following the title, please insert the following:

This is the U.S. national phase of International Application No. PCT/GB03/04406 filed October 10, 2003, the entire disclosure of which is incorporated herein by reference.

The heading on page 1, line 2 has been changed as follows:

Field of the ~~Invention~~ Disclosure

The paragraph beginning on page 1, line 3 has been changed as follows:

This ~~invention~~ disclosure relates to organic optical devices ~~comprising~~ including a layer of heat treated organic material and methods for the production thereof.

The heading on page 1, line 5 has been changed as follows:

Background of the ~~Invention~~ Disclosure

The paragraphs beginning on page 3, line 12 have been changed as follows:

It is therefore a purpose of the ~~invention~~ disclosure to improve the lifetime of organic semiconducting materials, in particular blue electroluminescent materials.

~~Summary of the invention~~ General Description

In a first aspect, the ~~invention~~ disclosure provides a method of forming an optical device ~~comprising~~ including the steps of:

The paragraphs beginning on page 4 line 11 have been changed as follows:

Preferably, the first electrode is an anode and the second electrode is a cathode. Preferably, the cathode ~~comprises~~ is a metal having a workfunction of less than 3.5 eV. More preferably, the cathode ~~comprises~~ is a layer of calcium.

Preferably, a layer of dielectric material is located between the polyfluorene and the cathode. Preferably, the layer of dielectric material ~~comprises~~ is a metal fluoride.

~~A method according to any preceding claim wherein~~ In a preferred embodiment, a layer of conductive organic material to provided between the first electrode and the first layer. Preferably, the layer of conductive organic material is PEDT / PSS.

Preferably, the polyfluorene ~~comprises~~ includes a plurality of regions including at least two of a hole transporting region, an electron transporting region and an emissive region.

Preferably, the polyfluorene ~~comprises~~ includes a hole transporting region, an electron transporting region and an emissive region.

The paragraphs beginning on page 4, line 24 have been changed as follows:

In a second aspect, the ~~invention~~ disclosure provides an optical device obtainable by the disclosed method ~~according to the first aspect of the invention.~~ Preferably, the optical device is an electroluminescent device.

In a third aspect, the ~~invention~~ disclosure provides a method of forming an optical device ~~comprising~~ including the steps of:

The paragraph beginning on page 5, line 10 has been changed as follows:

In a fourth aspect, the ~~invention~~ disclosure provides an optical device obtainable by the disclosed method ~~according to the third aspect of the invention.~~

Preferably, the optical device is an electroluminescent device.

The paragraphs beginning on page 5, line 15 have been changed as follows:

~~The inventors have surprisingly found that the~~ The lifetime of a polyfluorene, in particular a blue electroluminescent polyfluorene, may be improved by a combination of pre- and post-cathode heat treatment. This combination has been found to lead to a greater increase in lifetime than only one of either pre- or post-cathode heat treatment.

~~It has been found that the~~ The temperature of the heat treatment, in particular heat treatment above or below  $T_g$ , has little or no effect on lifetime. However, higher efficiency is maintained at temperatures around or below the  $T_g$  of the electroluminescent material.

The paragraphs beginning on page 5, line 23 have been changed as follows:

The ~~present invention~~ disclosure will now be described in further detail, by way of example only, with reference to the accompanying drawings in which:

FIGURE 1 shows a PLED or photovoltaic device prepared according to the method of the ~~invention~~ disclosure; and

FIGURE 2 shows a graph of luminance vs. time of a PLED according to the ~~invention~~ relative to devices not heated or subjected to only one of pre- or post-cathode heating.

The heading on page 6, line 1 has been changed as follows:

Detailed Description of ~~the Invention~~

The paragraph beginning on page 6, line 2 has been changed as follows:

With reference to ~~figure~~ Figure 1, a PLED or photovoltaic device prepared according to the disclosed method of ~~the invention~~ ~~comprises~~ includes a substrate 1, an anode 2 of indium tin oxide, a layer 3 of organic hole transport material, a layer 4 of organic semiconducting material or materials, an electron transporting layer 5 and a cathode 6.

The paragraph beginning on page 6, line 16 has been changed as follows:

Cathode 6 is selected in order that electrons are efficiently injected into the device and as such may comprise a single conductive material such as a layer of aluminium. Alternatively, it may ~~comprise~~ include a plurality of metals, for example a bilayer of calcium and aluminium as disclosed in WO 98/10621. A thin layer of dielectric material 5 such as lithium fluoride may be provided to assist electron injection as disclosed in, for example, WO 00/48258.

The paragraphs beginning on page 6, line 29 have been changed as follows:

The organic semiconducting material or materials ~~comprising~~ makeup of the layer 4 may be polymers or small molecules. Examples of suitable semiconducting polymers are disclosed in Adv. Mater. 2000 12(23) 1737-1750 and references therein. A single polymer or a polymer blend may be deposited from solution to form the layer 4. Where a plurality of polymers are deposited, they preferably ~~comprise~~ include a blend of at least two of a hole transporting polymer, an electron transporting

polymer and, where the device is a PLED, an emissive polymer as disclosed in WO 99/48160. Alternatively, the layer 5 may be formed from a single second semiconducting polymer that comprises regions selected from two or more of hole transporting regions, electron transporting regions and emissive regions as disclosed in, for example, WO 00/55927 and US 6353083. Each of the functions of hole transport, electron transport and emission may be provided by separate polymers or separate regions of a single polymer. Alternatively, more than one function may be performed by a single region or polymer. In particular, a single polymer or region may be capable of both charge transport and emission. Each region may comprise a single repeat unit, e.g. a triarylamine repeat unit may be a hole transporting region. Alternatively, each region may be a chain of repeat units, such as a chain of polyfluorene units as an electron transporting region. The different regions within such a polymer may be provided along the polymer backbone, as per US 6353083, or as groups pendant from the polymer backbone as per WO 01/62869.

In addition to the layer 4, the optical device may optionally ~~comprise~~ include further layers of organic semiconducting material. In particular, a plurality of layers of organic semiconducting materials may be provided as an alternative to a blend of those materials.

The organic semiconductor of the layer 4 is preferably a polyfluorene. Examples of suitable fluorene repeat units for a polyfluorene include 2,7-linked 9,9 dialkyl fluorenes, 2,7-linked 9,9 diaryl fluorenes, 2,7-linked 9,8 spirofluorenes (as disclosed in EP 0707020) and indenofluorenes (as disclosed in Adv. Mater. (2001), 13(14), 1096-1099).

The heat treatment of the optical device is preferably at temperatures up to and including the T<sub>g</sub> of the organic semiconducting material. Practically, the lowest

temperature for the heat treatment is around 60-70°C. The heat treatment may last from around ~~2~~ two minutes up to 12 hours, preferably around 10 minutes up to ~~4~~ one hour. The length of time of the heat treatment depends in part on the temperature - e.g. where heat treatment is at or around the T<sub>g</sub> of the organic semiconducting material, the time for the heat treatment is reduced accordingly. In addition, the efficiency of heat transfer from the heat source (e.g. a hotplate or an oven) to the optical device should be taken into account in determining this length of time. Heat treatment should take place in an inert environment, such as a nitrogen atmosphere, due to the susceptibility of organic semiconducting materials, and many cathodes, to degradation in air.

The optical device prepared according to the disclosed method ~~of the invention~~ is preferably a PLED when the first and second electrodes inject charge carriers. In this case, layer 4 is a light emitting layer.

The optical device is preferably a photovoltaic device or photodetector when the first and second electrodes accept charge carriers. In this case, the second layer preferably ~~comprises~~ is formed of a polymer or polymers capable of hole and electron transport.

The paragraph beginning on page 9, line 6 has been changed as follows:

A device was prepared in accordance with ~~example~~ Example 1 except that the device was not heated.

The paragraph beginning on page 9, line 8 has been changed as follows:

A device was prepared in accordance with ~~example~~ Example 1 except that the device was only subjected to pre-cathode heating.

The paragraphs beginning on page 9, line 11 have been changed as follows:

A device was prepared in accordance with ~~example~~ Example 1 except that the device was only subjected to post-cathode heating.

As can be seen from Figure 2, the lifetime of the device according to the ~~invention~~ disclosure was improved relative to any of the devices treated in accordance with the comparative examples.

The paragraph beginning on page 9, line 19 has been changed as follows:

Although the ~~present invention~~ disclosure has been described in terms of specific exemplary embodiments, it will be appreciated that various modifications, alterations and / or combinations of features disclosed herein will be apparent to those skilled in the art without departing from the spirit and scope of the ~~invention~~ disclosed method and device as set forth in the following claims.